

system is subjected to a rotation about the sink axis. Case rotation about this axis imparts a tangential component (relative to fixed coordinates) to the radially flowing fluid. Since angular momentum is conserved, a free vortex is generated, increasing the angular velocity of the fluid and resulting in an appreciable value at the sink relative to that at the wall. Tangential pitot tubes located near the center of rotation sense the dynamic pressure caused by the increase in tangential velocity of the fluid over the tangential velocity of the case. Both the sense and the magnitude of the input angular rate are contained in the pressure measurement.

In making a comparison between these two types of fluidic angular rate sensor the following conclusions are apparent. The jet unit has the advantage of simplicity, smaller size, smaller flow, smaller power requirements, and a much higher signal-to-noise ratio. The vortex type rate sensor must have a very high volume rate of flow to reduce

the transport delay time. The result of this is turbulence which introduces noise into the receiver area. The jet fluidic angular rate sensor operates at a low Reynolds Number (<500) which is well within the requirement for laminar flow. The vortex type rate sensor must have a large diameter since gain is proportional to diameter and it also requires a precision machining effort. The vortex type rate sensor has gone through approximately nine years of extensive development both by industry and by government as a rate sensor that is useful in fluidic systems. However, its limited dynamic range, high power requirement, and large size have limited its use to the all-fluid systems.

Development of the jet fluidic angular rate sensor continues in both theoretical and experimental areas to establish the performance capabilities and limitations of the basic sensor. It is expected that the sensor will find its way into shipboard systems and other applications where frequency response does not limit its usefulness.

ADDRESSES

Principal recent addresses made by APL staff members to groups and organizations outside the Laboratory.

The following four addresses were given at the 1968 Fall Meeting of the *American Physical Society*, Miami Beach, Florida, November 25-27, 1968:

- R. Turner and T. O. Poehler, "Far-Infrared Laser Diagnostics of Transient Plasma;"
- W. R. Powell, "Spectroscopic Measurement of Electron Concentration;"
- H. M. Stainer, "Some Consequences of Rotation in a Model Theta Pinch;"
- C. S. Leffel, Jr., "Ion Analysis of a Theta-Pinch Gun."

R. W. Cole, "Responsibilities, Activities, and Procedures of the Satellite Reliability Group at APL," *Baltimore Chapter, IEEE Reliability Group*, Baltimore, January 27, 1969.

D. D. Zimmerman and R. E. Hicks, "Preparation of Substrates with Bumps for Face-Down Bonding of Hybrid Components," *National Electronics Packaging Conference*, Anaheim, California, February 11-13, 1969.

M. H. Friedman, "Free Swelling of Biological Tissue. The Corneal Stroma," *American Institute of Chemical Engineers, 64th Annual Meeting*, New Orleans, Louisiana, March 17-20, 1969.

W. H. Avery, "Aerial Car Transit System," *New York University Seminar*, March 21, 1969.

V. O'Brien, "Large Circulating Drops in the Gravity Field," *International Union of Applied and Theoretical Mechanics, Symposium on Flow of Fluid-Solid Mixtures*, University of Cambridge, Cambridge, England, March 23-29, 1969.

The following three addresses were given at the *American Physical Society*, Philadelphia, March 24-27, 1969:

- F. J. Adrian, E. L. Cochran, and V. A. Bowers, "ESR Spectrum and Structure of HNO_2^- in KCl ;"
- F. J. Adrian, E. L. Cochran, and V. A. Bowers, "CN Stretching Vibration in HCN ;"
- J. Bohandy, J. C. Murphy, and A. N. Jette (APL) and D. O'Shea and C. M. Wilson (The Johns Hopkins University), "Raman Scattering in X-irradiated KCl-Ag Crystals."

L. Monchick, "Calculation of Ortho-Para Hydrogen Scattering Cross Sections," *The Johns Hopkins University, Department of Chemistry Colloquium*, Baltimore, March 25, 1969.

R. A. Dickman, "The Use of Functional Job Analysis as an Aid to Personnel," *American Personnel Guidance Association*, Las Vegas, Nevada, April 1, 1969.

A. A. Westenberg, "Atom-Molecule Kinetics Using ESR Detection," *Interagency Chemical Rocket Propulsion Group*, Cleveland, April 10, 1969.

W. E. Radford and R. L. Hickerson, "Measurement of Earth Magnetic Field Oscillations at Synchronous Satellite Altitudes," *1969 International Conference on Magnetism (INTERMAG)*, Amsterdam, The Netherlands, April 15-18, 1969.

K. Moorjani, "Elemental Amorphous Semiconductors," *Physics Department, University of Maryland*, College Park, April 17, 1969.

E. Maumenee, L. V. M. Hyvarinen, and T. George (The Johns Hopkins University), and J. T. Massey and B. F. Hochheimer (APL), "Fundus Camera for Retinal Fluorescence Cinematography," *Bascom Palmer Eye Institute, Department of Ophthalmology, University of Miami*, Miami, Florida, April 20-23, 1969.

ADDRESSES (continued)

The following two addresses were given at the *International Scientific Radio Union (URSI) Spring Meeting*, Washington, D.C., April 21-25, 1969:

T. A. Potemra and A. J. Zmuda, "The Effect of Dumped Particles on the Nighttime D-Region;"

A. J. Zmuda and T. A. Potemra, "The Relation of Geomagnetic Cutoffs to Long Distance VLF Path Disturbances and Riometer Absorption during the Solar Proton Event of September 2, 1966."

The following five addresses were given at the *American Geophysical Union Meeting*, Washington, D.C., April 21-25, 1969:

C. O. Bostrom, "Evidence for Magnetospheric Control of Polar Cap Struc-

ture in Low Energy Proton Intensities;"

M. L. Dwarkin, A. J. Zmuda, and W. Radford, "Magnetic Field Oscillations at Near Synchronous Altitude;"

S. M. Krimigis and J. A. Van Allen, (University of Iowa) "Solar Particle Observations with Mariner 5;"

S. M. Krimigis, "Initial Observations of Alpha Particles and Protons with Injun V;"

T. A. Potemra and A. J. Zmuda, "Ionospheric Disturbances Caused by the Solar Proton Events of May 23 and May 28, 1967."

K. Moorjani, "Elemental Amorphous Semiconductors," *Physics Department, Drexel Institute*, Philadelphia, April 24, 1969.

APL COLLOQUIA

Mar. 7—"Effects of Atmospheric Pollution on Climate," by R.A. Bryson, University of Wisconsin.

Mar. 14—"Progress Report on Micro-Sound Technology," by E. Stern, Massachusetts Institute of Technology.

Mar. 21—"Hijacking," by H. Hoekstra, Federal Aviation Administration.

Mar. 28—"Amorphous Semiconductors, New Physics, and a New Technology," by H. Fritzsche, University of Chicago.

Apr. 11—"Lightning," by M.A. Uman, Westinghouse Research & Development Co., Pittsburgh.

Apr. 18—"Memory," by L. Flexner, University of Pennsylvania.

Apr. 25—"Why Geysers are Faithful," by J.S. Rinehart, ESSA Research Laboratories, Boulder, Colorado.

WITH THE AUTHORS



W.H. Avery, co-author of the article on "Urban Transportation," has been represented twice previously in the *Digest*. He was the author of "Status and Future Trends in High Speed Chemical Propulsion" in the July-August 1965 issue and was a co-author of "Thermal Insulation for Hypersonic Vehicles," that appeared in the July-August 1962 *Digest*. Dr. Avery received the Ph.D. degree in physical chemistry from Harvard University in 1937 and

joined APL in 1947 as a Group Supervisor in the field of launching rocket development. He was later named Supervisor of the Launching and Propulsion Group and served in that capacity until 1961 when he was appointed Supervisor of the newly-organized Aeronautics Division, the position he still holds. Dr. Avery has served on numerous special panels and advisory committees of the Department of Defense, the National Academy of Sciences, and the National Aeronautics and Space Administration. From 1958 to 1964 he was a member of the Polaris Ad Hoc Group on Long Range Research and Development. He is a Fellow and Director of the American Institute of Aeronautics and Astronautics, a member of the Board of Directors of the Combustion Institute, and a member of the American Chemical Society and the American Physical Society.

Mrs. Gertrude S. McMurray, co-author of "Urban Transportation," is a native of Illinois and received her B.S. degree, with a chemistry major, in 1939 from the University of Illinois. Mrs. McMurray first joined APL as Associate Chemist in the Solid Propellant Infor-



mation Agency (SPIA) in 1948. In 1952 she left APL to join the editorial staff of the American Chemical Society publications. She rejoined SPIA in 1953 and was Project Supervisor of SPIA from 1959 to 1962. In 1960 she was named Senior Chemist and in 1963 she joined the Research and Development Office of the Aeronautics Division. Mrs. McMurray is a member of the American Chemical Society and the American Institute of Aeronautics and Astronautics.

WITH THE AUTHORS *(continued)*



T.M. Rankin, co-author of "Fluidic Angular Rate Sensor—A Replacement for Rate Gyroscopes?" is an earlier contributor to the *Digest*, having co-authored (with R.M. Rivello) "A Method of Analysis for Clamped-Free Cylindrical Shells," which appeared in the September-October 1963 issue. A native of Pennsylvania, he received his B.S. degree in aeronautical engineering and, in 1962, his M.S. in the same field, from the University of Maryland. Prior to coming to APL in 1962, Mr. Rankin was employed at the Naval Air Test Center, Weapon Systems Test Division, at Patuxent, Maryland. He is at present a staff member of the Inertial Project of the Missile Control Systems Group.

A.G. Moore, co-author of "Fluidic Angular Rate Sensor—A Replacement

for Rate Gyroscopes?" joined Hercules, Inc., in 1951 and since 1958 has been in the Quality Assurance Division at Allegany Ballistics Laboratory (ABL). Mr. Moore studied mathematics and physics in college and also radio, surveying, sound ranging, and instrument repair during three years in Army



technical schools. Mr. Moore's past assignments include inductive and magnetic proximity measuring systems, dc to dc linear variable differential transformers, linear motion strain-gage sensors, linear bidirectional flowmeters, and mono-filament-diameter measuring systems. For several years he has manufactured and marketed the Moore Electric Variometer, a rate of climb instrument for sailplanes. During the past two years his chief assignment at ABL has been on the fluidic angular rate sensor.



W.C. Schuemann, co-author of "Fluidic Angular Rate Sensor—A Replacement for Rate Gyroscopes?" received the degree of B.S. in electrical engineering from the University of Illinois in 1962. He joined Hercules, Inc., at the Allegany Ballistics Laboratory (ABL) in 1966 as a development engineer. Prior to joining ABL, Mr. Schuemann worked for the Coordinated Science Laboratory at the University of Illinois for nine years. There his responsibilities varied from the production and measurement of ultra-high vacua to inventing and developing a photocurrent suppressor gage that allowed measurement of very low pressures. Additional work centered around the electrostatic levitated gyro that originated at the Coordinated Science Laboratory. Since joining ABL, Mr. Schuemann's principal assignment has been to assist in developing the fluidic angular rate sensor.